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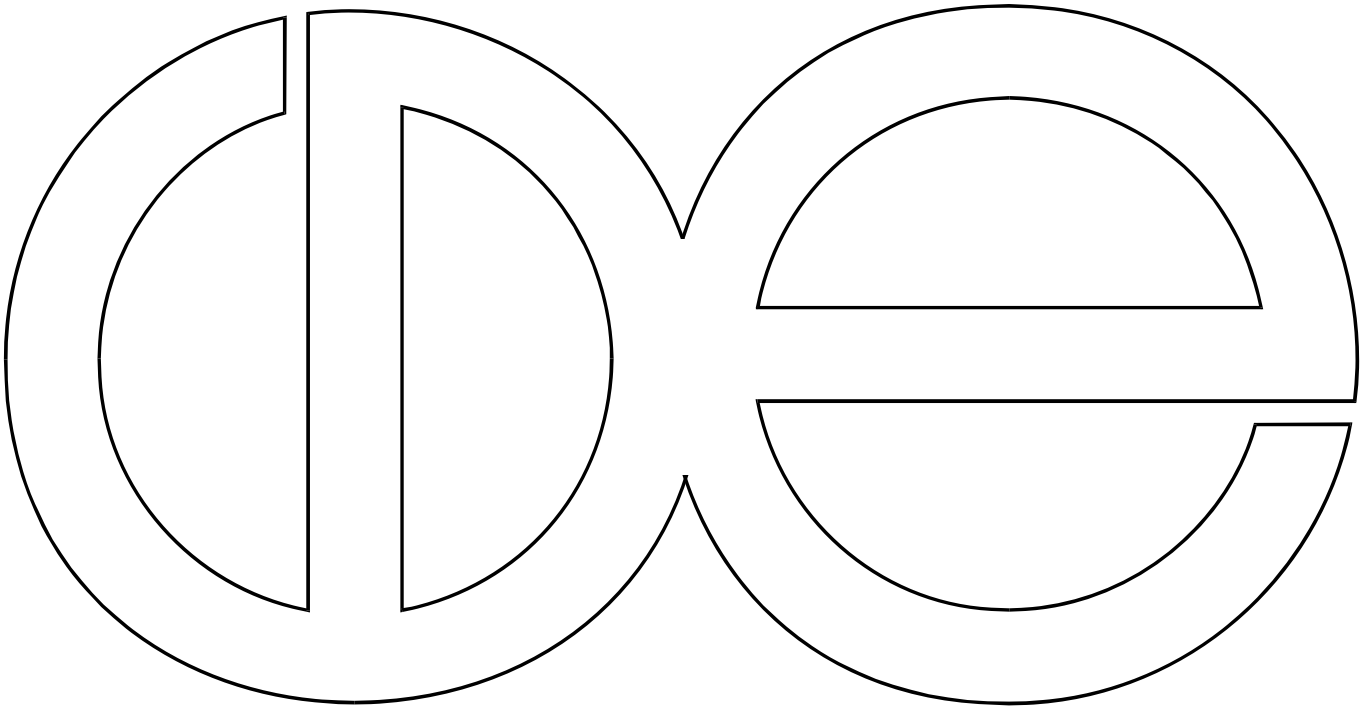

The Demography of Loneliness at Older Ages

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Abstract

This paper provides an empirical basis upon which to build research on the demography of loneliness at older ages. We proceed in two steps. In the first step, we use published life tables and data from the Health and Retirement Study (1998-2016) to calculate lonely life expectancy for Americans aged 55 and over. Using Sullivan's method, we demonstrate pronounced differences in lonely life expectancy by race/ethnicity and educational attainment that correspond to well-established patterns of stratification in other measures of well-being. In the second step, we estimate models that decompose observed racial/ethnic, educational, and regional differences in three key health outcomes into the part that is accounted for by loneliness and the part that is due to other factors. We find that loneliness appears to be particularly relevant for understanding health disparities with respect to educational attainment, especially among women. Loneliness is less important for understanding racial/ethnic health disparities. Anticipated growth in scientific and policy emphasis on loneliness and the fundamental life changes that have accompanied the Covid-19 pandemic makes continued investment in the development of a demography of loneliness at older ages even more important.

Introduction

Loneliness at older ages is currently the subject of much attention. Media accounts of a loneliness epidemic and references to loneliness as a public health crisis are abundant, the U.K. appointed a minister of loneliness, and the World Health Organization now defines social support networks as a determinant of health. In the U.S., loneliness has been linked to the rise in "deaths of despair" (Case and Deaton 2020) and evidence that loneliness is more pronounced at older ages, at the lower end of the socioeconomic distribution, and in rural areas (Carr 2019; Hawkley et al. 2008) suggests its role in health disparities among older Americans. Growth in scientific research on loneliness has been particularly notable in the fields of public health and psychology. The former typically examines relationships between loneliness and health outcomes while the latter focuses primarily on the definition and measurement of loneliness and documentation of its social and biological correlates. From this work, it is clear that loneliness is associated with a range of unfavorable health outcomes and that loneliness is multidimensional and manifests in different ways (Hawkley et al. 2005; Holt-Lunstad 2018; National Academies of Sciences, Engineering, and Medicine 2020; Perlman and Peplau 1981).

Research in sociology is more limited and has tended to focus on the related, but distinct, concept of social isolation, paying particular attention to social relationships and social network size and density, examining their correlates and their relationships with multiple measures of well-being (e.g., Carr et al. 2018; Cornwell and Waite 2009). Research on the demography of loneliness or loneliness as a dimension of social stratification in the U.S. is even more limited – a surprising research gap in light of widely shared interest in the (sub-)population prevalence of loneliness and its association with well-studied dimensions of stratification and inequality. It is also surprising given the aging of the U.S. population and the documented importance of social

interaction and emotional support for health and other dimensions of well-being in later life (Berkman et al. 2000; Hughes et al. 2004; Waite 2018).[1]

In this paper, we take a first step toward a better understanding of the demography of loneliness at older ages by describing change over time in the prevalence of loneliness among Americans in mid- and late-life (age 55 and above) and how the prevalence of loneliness differs across three dimensions of social stratification – race/ethnicity, socioeconomic status (as proxied by educational attainment), and region of residence (large metropolitan counties vs. less-populated counties). After providing a demographic summary of trends in multiple measures of loneliness using the intuitive, but underutilized, metric of lonely life expectancy, we also examine the role of loneliness in shaping health disparities. These analyses focus on three key health outcomes at older ages (onset of disability, onset of cognitive impairment and dementia, and mortality) and decompose observed racial/ethnic, educational, and regional differences in these outcomes into the part that is accounted for by loneliness and the part that is due to other factors. Our calculation of lonely life expectancy provides intuitive summary measures of trends in both loneliness and mortality across later life and differences by established dimensions of social stratification. Our analyses of health disparities provide an initial descriptive assessment of the degree to which differences in loneliness do (or do not) help us to understand health disparities at older ages.

[1] But see Hansen and Slagsvold (2016), Sundstrom et al. (2009), and numerous studies by de Jong Gierveld, Dykstra, and colleagues on loneliness at older ages in the Netherlands and other Western European countries.

Background

What is Loneliness?

Loneliness is, of course, easy to understand at an intuitive level. Its formal definition in the scientific literature is similarly straightforward: the "feeling of social isolation that accompanies perceived deficiencies in the number or quality of one's social relationships" (Hawkley et al. 2008: S375). It is much more difficult, however, to adequately measure loneliness in the context of a social survey. Of particular importance are the facts that loneliness is a subjective state that can be either temporary or chronic, that loneliness is distinct from the more objectively measurable concept of social isolation, that stigma associated with loneliness can lead to underreporting, and that carefully validated measures of loneliness are not typically included in social surveys (e.g., de Jong Gierveld 1998; Waite 2018).[2] The resulting inconsistency in the use of the term and in its empirical measurement has hampered efforts to develop a solid empirical understanding of the prevalence of loneliness, trends over time, its correlates, and its relationships with health and other dimensions of well-being.

Scholars regularly emphasize the distinction between social isolation and loneliness, noting that it is possible to be socially isolated but not feel lonely. Similarly, it is clear that some people feel lonely despite being surrounded by family and friends (i.e., not isolated). While the two concepts are clearly related (Pinquart and Sorensen, 2003), it is important to emphasize that

[2] In contrast to loneliness, social isolation is defined as the objective state of having limited contact with others (Carney et al. 2016). Closely related terms include social integration, social connectedness, and social inclusion/exclusion, all of which are linked to "successful aging" (Rowe and Khan 1997).

widely used measures of each are typically not highly correlated (Hughes et al. 2004; Schnittker 2007), that both appear to have independent relationships with health outcomes (Cornwell and Waite 2009), and that relationships between the two appear to depend upon social and cultural context (e.g., Jylhä and Jokela 1990; Sundstrom et al. 2009). It is also important to recognize that demographic research has typically focused on relationships between health (physical, mental, and emotional) and social isolation and has paid less attention to loneliness.

Measurement of Loneliness

Validated, multi-item measures of loneliness are not included in many surveys, meaning that much of the extant research on loneliness at older ages is based on a single question included in the CES-D scale of depressive symptomatology (Radloff 1977). This question, included in most large-scale surveys of older adults, asks respondents "How often in the past week (two weeks, month) have you felt lonely?" Typical response options are "all of the time," "most of the time," "some of the time," and "never."[3]

Efforts to more comprehensively measure loneliness have produced indices such as the Revised UCLA Loneliness Scale (Russell et al. 1980, 1996), the de Jong Gierveld Loneliness Scale (de Jong Gierveld 1987; de Jong Gierveld and Van Tilburg 2006), the NSHAP Felt Loneliness Measure (NFLM) (Payne et al. 2014), and the Cornwell Perceived Isolation Scale (Cornwell and Waite 2009). The original 20-item UCLA Loneliness Scale was designed to be administered face-to-face and is considered too long for telephone interviews (Hughes et al.

[3] In some surveys, including the Health and Retirement Study (which we use), respondents were asked in most waves whether they felt lonely "much of the time," with a simple "yes" or "no" response option.

2004), thus prompting the development and use of abbreviated versions. The eleven-item and three-item versions are used widely in both research and clinical settings in the U.S. as a brief assessment of loneliness. The de Jong Gierveld loneliness scale is typically a six-item version of an 11-item scale that captures both emotional and social loneliness via questions about feelings of emptiness and rejection, missing having people around, and having people who you trust, can rely on, and feel close to. The NFLM and the Cornwell Perceived Isolation Scale build upon, and are similar to, the 3-item UCLA index used in the HRS (Cornwell and Waite 2009; Payne et al. 2014).

Prevalence and Correlates of Loneliness

The prevalence of loneliness, like any outcome, depends on how it is measured, with meta-analyses indicating that the percentage of older Americans reporting frequent and occasional feelings of loneliness ranges between 5-15 percent and 20-40 percent, respectively (Pinquart and Sorensen 2001). More recent surveys also indicate that the prevalence of loneliness in the U.S. ranges between 20-35 percent (National Academies of Sciences, Engineering, and Medicine 2020). Data from the National Social Life, Health and Aging Project and from the Health and Retirement Study show that the percent of older Americans with values of four or greater on the Revised UCLA Loneliness Scale and NFLM has remained stable in recent years at around 30% (Hawkley et al. 2019).[4] It is also clear that the prevalence of loneliness at older ages varies markedly across countries, with higher levels documented in Eastern Europe than in Western and

[4] This evidence of relative stability in the prevalence of loneliness contrasts with media depictions of an "epidemic of loneliness" (Health Resources & Services Administration 2019; McGregor 2017; Murthy 2017; Ninivaggi 2019).

Northern Europe (de Jong Gierveld et al. 2012; Hansen and Slagsvold 2016; Jylhå and Jokela 1990). Research on other countries indicates that, as in the U.S., the prevalence of loneliness at older ages has been relatively stable over time (Dahlberg et al. 2018; Victor et al. 2002).

Several studies have examined relationships between loneliness and sociodemographic characteristics such as sex, race/ethnicity, age, educational attainment, health, employment status, and marital status. Findings vary somewhat across individual studies, but they typically indicate that older women are somewhat more lonely than men (but see Maes et al. 2019), that loneliness is higher among Blacks and Hispanics relative to Whites, that age is positively associated with loneliness, particularly among the oldest old, and that socioeconomic status (SES), employment, good health, and presence of a partner/spouse are inversely associated with loneliness (e.g., Hawkley et al. 2008, 2019; Pinquart and Sorensen 2003; von Soest et al. 2020). Multivariate analyses have shown that much of the racial/ethnic gradient in loneliness reflects lower levels of income and educational attainment among Blacks and Hispanics (Hawkley et al. 2008) and it also appears that greater isolation among immigrants may contribute to higher levels of loneliness among Hispanics (Viruell-Fuentes et al. 2013). Other studies show that loss of spouse and living alone (a measure of social isolation) tend to be associated with loneliness (Chen and Short 2008; de Jong Gierveld et al. 2012; de Jong Gierveld and Van Tilburg 1999; Russell 2009). Although recent research on deaths of despair and declining life expectancy among lower-SES Whites in the U.S. suggests a higher prevalence of loneliness in rural areas, research on regional differences in loneliness is limited and results are mixed. Some find a higher prevalence of loneliness in rural areas (e.g., Finlay and Kobayashi 2018) while some conclude the opposite (e.g., MacDonald et al. 2020). Taken as a whole, these findings from previous research indicate a need for systematic incorporation of loneliness and its relationships with

family structure and social support into demographic research on social stratification and inequality at older ages.

As a first step, it is important to better understand how the prevalence and duration of loneliness vary across key dimensions of social stratification – a task that is complicated by the subjective, often transitory, nature of loneliness. To the extent that longer exposure to loneliness, or chronic loneliness, is particularly detrimental for health outcomes of interest, addressing this limitation in a meaningful way will be an important contribution. The ability to observe the same individuals over time in panel surveys is helpful, but in most surveys the duration between waves is arguably too long to effectively measure trajectories of loneliness at the individual level. It is possible, however, under some assumptions, to characterize exposure to loneliness across later life for specific aggregations of individuals. We describe and implement this approach below to produce measures of lonely life expectancy beyond age 55. This measure is analogous to widely used measures of healthy life expectancy or disability-free life expectancy (Crimmins and Saito 2001; Robine and Ritchie 1991) and offers an intuitive metric for summarizing both mortality and the prevalence of loneliness across later life for synthetic cohorts. To our knowledge, this is the first effort to construct measures of lonely life expectancy.

Loneliness and Health at Older Ages

A substantial body of research on relationships between loneliness and health at older ages in public health demonstrates that loneliness is associated with a range of unfavorable health outcomes including, but not limited to, mortality (Holt-Lustad et al. 2015; Luo et al. 2012; Patterson and Veenstra 2010), worse self-rated health (Hawkley et al. 2016), depression (Cacioppo et al. 2006; Luo et al. 2012), cognitive impairment (Wilson et al. 2007), functional limitations (Luo et al. 2012;Warner and Kelley-Moore 2012), and poor sleep (Cacioppo et al.

2002). Understanding these relationships is complicated by the fact that causal influences go in both directions, i.e., loneliness may contribute to health decline and poor health can also contribute to higher levels of loneliness (Pinquart and Sorensen, 2003; Warner and Adams 2016).

Explanations for these relationships between loneliness and health are varied. Some studies have emphasized the role of health behaviors (e.g., exercise, smoking, diet) in explaining relationships between loneliness and heath (Patterson and Veenstra 2010). Others emphasize the confounding role of sociodemographic characteristics like marital status (Carr et al. 2018; von Soest et al. 2020). Studies of loneliness and mortality emphasize the relationship between loneliness and morbidity in explaining the elevated risk of death among those who report being lonely (e.g., Luo et al. 2012). Many studies find that associations between loneliness and morbidity/mortality remain significant net of a wide range of posited correlates, suggesting a potentially causal relationship. Support for this conjecture can be found in recent research documenting physiological/genetic linkages (e.g., cardiovascular, immune) between loneliness and health outcomes (Goossens et al. 2015; see also National Academies of Sciences, Engineering, and Medicine 2020, chapter 5, for a summary of related research).

Despite evidence that loneliness is correlated with key dimensions of social stratification, there has been relatively little effort to document the role that loneliness may play in shaping health disparities by race/ethnicity, SES, and region of residence. Health disparities at older ages are widely recognized as a critical research focus in the aging and highly stratified U.S. population (Hummer et al. 2004), and a fuller understanding of the underlying sources and mechanisms will benefit from attention to relationships between loneliness and health. However, most research on loneliness and health inequality has simply included dimensions of social

stratification such as race/ethnicity and education as covariates (e.g., Cacioppo et al. 2002, 2006; Hawkley et al. 2010; Luo et al. 2012; Sutin et al., 2020; Wilson et al. 2007). Similarly, research on SES as a fundamental cause of health inequality and on racial differences in health/mortality have rarely considered, conceptually or empirically, the potential role of loneliness in shaping disparities in health outcomes (Hayward et al. 2000; Link and Phelan 1995; Phelan et al. 2004). Several key questions thus remain unanswered. Chief among them are: To what extent do differences in loneliness account for socioeconomic and racial/ethnic differences in health at older ages? Does this relationship depend on the health outcome considered? For example, does loneliness account for more (or less) of observed disparities in mortality than in the onset of cognitive impairment? To answer these questions, we extend previous research on loneliness and health by estimating models for the onset of health conditions, as a function of multiple dimensions of social stratification, that partition these relationships into components that are and are not accounted for by loneliness.

Data and Method

We address our research questions in three steps. In the first, we summarize the prevalence of different measures of loneliness across time and by age (from 55 to 100), focusing on differences by sex, race/ethnicity, educational attainment, and region of residence. In the second, we produce measures of lonely life expectancy separately across categories of these variables. In the third, we estimate models for three health outcomes (physical disability, cognitive impairment, and mortality) to quantify the direct and indirect pathways through which loneliness is related to disparities in these health outcomes.

Data

The primary source of data for these analyses is waves 4-13 of the Health and Retirement Study (HRS, 1998-2016) provided by RAND (2016 V1 file). We start from the year 1998 because wave 4 of the HRS (conducted in 1998) was the first to include a representative sample of the population age 55 and over.[5] Our analyses of lonely life expectancy require a second source of data – published life tables, by sex and by race/ethnicity, for the U.S. population for the period of interest. We used a total of 19 annual life tables (for the period 1998-2016) downloaded from the Human Mortality Database (https://www.mortality.org/) to construct life tables for two periods (1998-2006 and 2008-2016). We do this by using mean values of the age-specific probabilities of dying (q_x) to construct summary life tables representing average levels of mortality for each of the two time periods.[6]

Measurement

The HRS contains three measures of loneliness, one asked of all respondents in all waves and the other two asked since 2006 in the leave-behind Psychosocial and Lifestyle Questionnaire given to a rotating (random) 50% subsample of the core panel participants who completed the

[5] Weighted HRS data are representative of the U.S. population. We use sampling weights (RWTRESP) in all analyses to reflect oversampling and patterns of differential non-response that may be related to loneliness and to health (e.g., age, marital status, race/ethnicity, region of residence).

[6] Because the CDC has produced separate life tables for Hispanics only since 2006, our life table for Hispanics in the first period (1998-2006) is based on mortality data for only one year and thus overstates Hispanic life expectancy for that period.

enhanced face-to-face interview.[7] The former is a single yes-no question (since wave 2) included in the CES-D index that asked respondents whether they felt lonely for much of the time during the past week.[8] The latter two are 3- and 11-item indices based on the 20-item Revised UCLA Loneliness Scale (Russell 1996; Russell et al. 1980; Smith et al. 2017). Questions included in the 3-item measure ask respondents how much of the time they feel lack of companionship, left out, and isolated from others (items a-c). These three questions have been included in the HRS Psychosocial and Lifestyle Questionnaire since 2006.

Beginning in 2008, the HRS added eight more items to the 3-item scale based on published factor loadings in order to enhance reliability and to allow researchers to determine potential sub-dimensions of loneliness. Respondents were asked how much of the time they feel in tune with the people around him/her, alone, there are people he/she can talk to, there are people he/she can turn to, there are people who really understand him/her, there are people he/she feel close to, part of a group of friends, he/she has a lot in common with the people around him/her (items d-k). For all items, response options are "1-often," "2-some of the time," and "3-hardly ever or never." We use the 11-item UCLA loneliness scale for its enhanced reliability among older adults (Lee and Cagle 2017).[9] The summed index ranges from 11 to 33, with higher values representing more loneliness. To construct measures of lonely life expectancy (as described below), we dichotomize

[7] In 2004, the HRS developed a pilot Participant Lifestyle Questionnaire and administered it as a leave-behind self-administered questionnaire to a pilot sample of about 4,000 respondents. Please see Smith et al. (2017) for details.

[8] In wave 1, options for this loneliness item range from 1-all or almost all of the time, 2-most of the time, 3-some of the time, and 4-none or almost none of the time.

[9] Results are similar when we use the 3-item version.

this measure by defining as lonely those whose score is in the highest quartile of the distribution (calculated separately for men and for women). Levels of loneliness are obviously sensitive to where this threshold lies, but our general conclusions are not sensitive to alternative dichotomizations and our approach is similar to that in one of the few other studies to use a categorical version of this index (Cacioppo et al. 2002).

Our three health outcomes are measured as follows. First, disability was measured based on reported difficulties with five activities of daily living (ADL) (walking across the room, dressing, bathing, eating, getting in and out of bed). Beginning in wave 2, HRS respondents were asked if they have difficulty with each of these activities, and disability is constructed as a dummy variable with 1 indicating difficulty with at least one activity and 0 indicating no difficulties. We are interested in the onset of disability – i.e., the presence of disability at wave $t+1$ among those with no functional limitations at wave t. Second, following prior practice (e.g., Crimmins et al. 2011; Stephan et al. 2017; Sutin et al. 2020), we measured cognitive impairment using the modified Telephone Interview for Cognitive Status (TICSm). The RAND data file includes a 27-point composite cognitive score calculated by summing scores of immediate and delayed recall test (to assess short-term memory), a serial 7 subtraction test (to assess working memory), and a backward counting test (to assess mental processing speed). This cognitive measure is available in wave 2 (for certain cohorts) and waves 3 to 12. We constructed a three-category measure of cognitive impairment with scores of 12 to 27 representing normal cognitive function (assigned the value 0), scores of 7 to 11 indicting cognitive impairment without dementia (CIND) (assigned the value 1), and scores equal to or less than 6 indicating dementia (assigned the value 2). Our interest is the presence of CIND and dementia at wave $t+1$ among those who have normal cognitive function at wave t. Finally, for respondents who have died, year and month of

death are included in the HRS Tracker File and the RAND Longitudinal File. Mortality status at wave *t +1* was ascertained based on this information (0 = alive, 1 = died).

Our key independent variables are measured as follows. Race/ethnicity distinguishes Whites, Non-Hispanic Blacks, and Hispanics (of any race). HRS respondents identifying as other racial/ethnic groups (e.g., Asian-Americans) are few in number and thus excluded from our analyses. Educational attainment is a three-category measure based on reported highest level of schooling completed – less than high school, high school (including GED), and more than high school (some college, bachelors degree and above). Region of residence is a dichotomous variable that distinguishes respondents who live in large metropolitan areas from those living in smaller areas. This variable was constructed based on HRS recodes of values for the Beale urban-rural continuum. Large metropolitan areas include counties with populations of 250,000 or more (rural-urban continuum values of 1 and 2) and other areas are all counties with populations of less than 250,000 (rural-urban continuum values of 3-9).

In the health models, we control for other sociodemographic covariates at wave *t* that could be associated with both self-reported loneliness and health outcomes. These include respondents' sex (1 = male, 0 = female), age (in years) and age squared, marital status (0 = married, 1 = never married, 2 = separated/divorced/widowed), working status (0 = working full-time, 1 = working part-time, 2 = retired/partly retired, 3 = unemployed/not in the labor force) and logged household total income in previous year (adjusted for inflation, with 2015 as the index year). To reduce confounding by earlier health conditions when predicting later health outcomes, we use one summary index of functional status, the large muscle index, to reflect respondents' overall

objective health status at the first wave in which they were observed in the survey.[10] Functional status summarizes overall health and is related to other health measures in theoretically meaningful ways (Wallace and Herzog 1995). The large muscle index is constructed from questions asking respondents whether they have some difficulty in sitting for two hours, getting up from a chair, stooping, kneeling or crouching, and pushing or pulling large objects, and scores range from 0-4, with higher values indicating worse functional status and health.

After excluding observations with missing values on the measures of loneliness, we are left with a maximum analytical sample of 31,513 respondents aged 55 and over who provided 157,002 person-waves of data. Analytical sample size varies across different analyses depending on sample restrictions and the number of non-missing observations for the three health measures and covariates. For analyses using the CES-D loneliness measure, the final analytical sample ranges from 14,721 respondents with 60,674 observations for cognitive impairment to 28,711 respondents with 138,231 observations for mortality. The final analytical sample size is smaller when using the 11-item UCLA loneliness scale, ranging from 7,982 respondents with 10,000 observations for cognitive impairment to 16,230 respondents with 24,665 observations for mortality. Detailed information on analysis-specific sample size is provided in Appendix Table 1.

[10] The large muscle index is missing for the HRS AHEAD entry cohort respondents in wave 2. For these respondents, we use their large muscle index values in waves 3 or 4 to reflect the baseline objective health, as our analyses are based on waves 4-13.

Analytical Strategy

Life Tables

Because loneliness is not, and cannot be, measured in a way that allows us to observe the timing of transitions into and out of the state, it is not possible to estimate conventional multistate life tables. Instead we use Sullivan's method, the approach commonly used to measure healthy life expectancy or disability-free life expectancy (Imai and Soneji 2007). If we assume that loneliness, as measured in the HRS, is stable at the individual level for periods of one-year, Sullivan's method is a straightforward and effective means of measuring lonely life expectancy. Because this assumption of individual-level stability is presumably not realistic, it is important to note that it is not necessary – it is only necessary that the proportion of individuals defined as lonely within a given group of interest (e.g., 70-year-old men living in large metropolitan areas) remain stable for one-year periods. Our synthetic cohort analyses rely on this assumption and results should be evaluated with that in mind.

While it is straightforward to calculate age-specific proportions of respondents who feel lonely by race/ethnicity, educational attainment, and region of residence, it is more challenging to produce the corresponding life tables. Because official life tables are produced only by sex and race/ethnicity, we use the procedure proposed by Dudel and Myrskylä (2017) to construct life tables for different categories of educational attainment and regions of residence. The first step in this procedure is to use HRS data to estimate sex-specific models of mortality beyond age 55 as a function of age and educational attainment or region of residence.[11] The age-specific

[11] We estimate discrete-time event history models using logistic regression, separately for men and women, with the log-odds of death specified as a quadratic function of age. We do not

probabilities of dying generated from these mortality models allow us to construct life tables separately for each combination of time-period, sex, and categories of educational attainment or region of residence. These group-specific life tables are then adjusted, using information about age-specific probabilities of death from the sex-specific life tables published by CDC and weighted sums of the estimated q_x values where the weights are the observed age-specific distributions of respondents by educational attainment or region of residence. Adjusting group-specific q_x values so that their weighted sum equals the observed values in the published life tables ensures that overall levels of life expectancy estimated based on HRS data are identical to those based on vital statistics data (see Dudel and Myrskylä 2017 for details on this procedure for constructing group specific life tables whose weighted sum is equivalent to life tables for the whole population).

While it is possible to use simple tabulations of loneliness, we choose instead to estimate logistic regression models for the 0-1 measures of loneliness as a function of age and age squared and use the predicted values from these models. This data smoothing procedure minimizes the impact of small cell size and associated fluctuation in the prevalence of loneliness (e.g., there are relatively few black male respondents at very old ages). These predicted values are then used to partition the age-specific years of life (L_x) in the life tables described above to produce years of life lonely and not lonely that can be re-summed to produce measures of lonely life expectancy. Previous research has shown that state-specific life expectancies produced using Sullivan's method are very similar to those from life tables generated via the estimation of multi-state

include race/ethnicity in the models because it is not necessary to construct race-specific life tables as they already exist.

models (Imai and Soneji 2007; Mathers and Robine 1997).

Decomposition

To quantify the potential role of loneliness in accounting for health disparities by key social stratification indicators, we use the Karlson-Holm-Breen (KHB) method (Breen et al. 2013, 2018; Karlson et al. 2012) to decompose the total effects of race/ethnicity, educational attainment, and region (after conditioning on covariates) on the above three health outcomes into direct effects and indirect effects via loneliness. Specifically, we use the khb command in Stata to estimate binary logistic regression models for the onset of disability and mortality and multinomial logistic regression models for the onset of cognitive impairment. In all models, we control for respondents' age, age squared, marital status, work status, logged household total income, and the baseline large muscle index when estimating each outcome. These decompositions are implemented separately by sex. To detect any temporal changes, we conduct decompositions using the CES-D loneliness measure during three time periods: 1998-2016, 1998-2006, and 2008-2016. Since the 11-item UCLA Loneliness scale was only included since 2008, decompositions using this measure are only for the period 2008-2016.

Results

Trends in Loneliness

Figure 1 presents mean values of the two dichotomous measures of loneliness (the CES-D loneliness question and the top quartile of the 11-item UCLA loneliness scale), separately for men and women between 1998 and 2016. From this figure, it is clear that the prevalence of loneliness has remained relatively stable over the past two decades and that the absolute and relative prevalence of loneliness depends upon how it is measured. The prevalence of loneliness varies between 12% and 21% using the single-item CES-D measure and between 25% and 32%

using the 11-item UCLA index dichotomized at the 75th percentile. Using the CES-D measure, women appear more lonely than men, but the reverse is true when we use the UCLA measure. These data provide no evidence of the frequently referenced epidemic of loneliness at older ages.

Figure 2 presents mean values of the CES-D measure of loneliness, by sex, for different categories of race/ethnicity, educational attainment, and region of residence. These figures show pronounced gradients in loneliness for both men and women by race/ethnicity, and educational attainment, but not by region of residence. Loneliness is inversely related to educational attainment and Whites are less lonely than Blacks who are less lonely than Hispanics (among women).

[Figures 1 and 2 here]

Lonely Life Expectancy

Table 1 presents values of lonely life expectancy at age 55 using the CES-D measure, separately for the two time periods, by sex and the three stratifying variables. Looking first at the results for men in the upper panel, we see that lonely life expectancy is markedly higher for Hispanics and those with less than a high school education. Indeed, a 55-year-old Hispanic man in the synthetic cohort constructed from 1998-2006 data is expected to spend six and half years of his remaining life lonely, over three years more than his White counterpart. Similarly, men in the lowest educational group are expected to spend two more years lonely relative to their highly educated counterparts. When we account for differences in mortality by calculating the percent of remaining life lonely (rather than absolute years), we see that Hispanics and men without a high school education spend twice as much of their remaining lives lonely, relative to Whites and men who attended some college or more. Differences between men and women living in large metro areas and those living elsewhere are small.

[Table 1 here]

These same general patterns of differentials hold for the synthetic cohorts constructed based on data from 2008-2016. Interestingly, these results indicate that lonely life expectancy in late mid-life has declined over time for almost all groups of Americans. This trend reflects a slight decline in the years of remaining life lonely combined with a 1- to 2-year increase in overall life expectancy across the two time periods. The decline in years of lonely life expectancy was particularly pronounced for Black and Hispanic men, White and Black women, and men and women living outside of large metropolitan areas.

Health Disparities

We now turn to estimation of the indirect role of loneliness in explaining health disparities by race/ethnicity, educational attainment, and region of residence. Although we use the language of "effects" when presenting results, we emphasize that estimated relationships are associational. In general, analyses using the CES-D measure show that loneliness accounts for a significant part of observed health disparities in disability and mortality, but not cognitive impairment. Because these patterns do not differ systematically over time, we present results for the entire time period of 1998-2016 (results for each of the two sub-periods are available upon request).

Table 2 presents the result of decomposition analyses of the effects of race/ethnicity, educational attainment, and region of residence on disability, separately for men and women. Comparing the top rows of panels A and B (the total effect), we see the expected strong and statistically significant racial and educational gradients in onset of disability: Blacks and Hispanics are more likely to become disabled relative to Whites (the reference category) and those with more education are less likely to become disabled relative to those with less than a high school degree (the reference category). The third row of panels A and B shows how much of

these disparities in the onset of disability are accounted for by loneliness, as measured by the CES-D question. Loneliness plays a minimal role in explaining racial/ethnic differences in disability for men, but accounts for a significant 10% of observed differences in disability onset between Hispanic women and White women. Note that these are results from the full model including all covariates. Results from simple models including only respondents' age and age squared (not shown) indicate a substantially larger racial gradient in disability – particularly between Black men and White men – and a larger role of loneliness in accounting for racial disparities (10%-12% among men and 16% between Hispanic and White women). Loneliness plays a similarly important role in explaining the educational gradient in disability: it accounts for 11%-13% of the observed differences in disability onset between those with more education and those without a high school degree among men and 8%-10% of the difference among women. The indirect role of loneliness in simple models is similar for men and slightly larger for women. In contrast, there is no significant regional variation in disability for loneliness to account for, even in the simple models.

[Table 2 here]

Results for mortality in Table 3 also indicate strong racial and educational gradients but no regional differences (top rows of panels A and B): Hispanic men and women have a lower likelihood of dying and Black women's mortality risk is marginally higher than that of White women. In the model without covariates, the mortality gap between Black men and White men is statistically significant and almost four times the size of that in the full model, and the gap between Black and White women is twice that in the full model. Higher education is associated with lower mortality, and the gradient is also larger in the simple model. Net of covariates, loneliness does not explain racial/ethnic differences in mortality, indeed the Hispanic mortality

advantage becomes larger after controlling for their higher levels of loneliness. In the simple models, however, loneliness accounts for 16% of the mortality difference between Black men and White men and 10% of the difference between Black women and White women. In contrast, loneliness continues to play a significant role in explaining the educational gradient in mortality net of covariates, for both men and women: about 7% of the mortality gap between men with a college degree and those who did not complete high school is accounted for by differences in loneliness, and this percentage is even higher (14%) for the gap between men with high school degree and those without. Among women, the corresponding indirect components (via loneliness) in mortality differences are 9%-12% (third rows of panels A and B).

[Table 3 here]

Finally, the results in Table 4 show substantial racial and educational gradients in the onset of cognitive impairment, similar to those observed for disability and mortality. Interestingly, people living in less populous counties are more likely to experience CIND and dementia compared with their counterparts living in large metropolitan areas (top rows of panels A and B). However, loneliness does little to account for cognitive health inequalities among men (third rows of panels A and C). Among women, loneliness plays a significant, but substantively small, role in shaping inequalities in cognitive outcomes by education and race/ethnicity: 2-4% of differences in both CIND and dementia. Unlike disability and mortality, the indirect role of loneliness in explaining cognitive impairment depends little on whether we control for covariates, suggesting the relevance of other factors not included in our models.

[Table 4 here]

Decomposition results using the 11-item UCLA loneliness scale for the more recent time period (2008-2016) yield qualitatively similar findings (although the reduced sample size results

in less precise estimates). Strong educational and racial disparities exist for all health outcomes, and loneliness appears to play a larger role in explaining educational gradients among women than among men. For disability (Table A2), loneliness accounts for 16.8% (significant at $p < .10$) of the estimated difference in the likelihood of developing a disability between highly educated women and women who did not complete high school. However, loneliness plays a minor and insignificant role in accounting for the strong racial/ethnic gradient in disability onset for both men and women. For cognitive impairment (Table A3), loneliness plays a much smaller role in accounting for estimated disparities: Among women, but not men, loneliness accounts for about 4% of the difference in CIND onset between those with at least a high school education and those who did not complete high school. Finally, for mortality (Table A4), loneliness does not have significant indirect effects among men, but explains 11.8% of differences in mortality between highly educated women and those with less than high school degree.

Discussion

Research on loneliness and well-being is a burgeoning field in which the work of demographers and stratification scholars is not well represented. This is a critical limitation in light of the many important advances in research on loneliness in public health and psychology as well as the obvious relevance for demographers of trends in loneliness, differentials in loneliness, and the role of loneliness in contributing to health disparities. Our goal in this paper was to use basic demographic tools – lifetable analysis and decomposition analysis – to provide an empirical basis for subsequent research on the demography of loneliness at older ages.

Like other recent studies, our results provide no evidence of an "epidemic of loneliness" in the U.S. While the prevalence of loneliness at older ages can been seen as high (with levels depending on how it is measured), it has remained remarkably stable over the past two decades.

We also showed that, under some plausible assumptions, it is clear that older Americans spend several years of their remaining life in a state of loneliness and that racial/ethnic and educational differences in lonely life expectancy are pronounced. These analyses also showed that lonely life expectancy has declined in recent years due to a combination of declining mortality and stable levels of loneliness. We view our findings of racial/ethnic and educational differentials in lonely life expectancy as an important extension of the large body of research on healthy life expectancy or disability-free life expectancy demonstrating that Americans experience later life in very different ways depending on their race/ethnicity and SES (as proxied by educational attainment). Well-documented relationships between loneliness and a wide range of health outcomes suggest that differences in lonely life expectancy play an important role in shaping health disparities. Life tables, however, can provide little insight into the nature of that role.

In an effort to address this limitation of life table analysis, we estimated models for the onset/experience of three important health outcomes that allow for portioning of health disparities into direct pathways and indirect pathways through loneliness. That is, we decomposed educational differences in mortality (for example) into the effect of differences in loneliness and the effect of all other factors (not included in the models). The results of these analyses demonstrate that in some, but not all, cases, loneliness appears to be particularly important for understanding educational health disparities, with 7-14% of the negative educational gradient in disability and mortality accounted for by higher levels of loneliness among men and women at the lower end of the educational spectrum. We view this as a compelling invitation for demographers of health and aging to more regularly incorporate measures of loneliness into their models of health disparities.

Of course, there are many limitations to our simple descriptive analyses. First, our synthetic

cohort estimates of lonely life expectancy constructed using Sullivan's method provide no information about the (in)stability of loneliness across later life for individuals of varying sociodemographic profiles. Distinguishing transient feelings of loneliness from chronic loneliness, and better understanding how each is related to health outcomes of interest, is of critical importance, but is also extremely difficult given the relatively long intervals between survey waves of the HRS and other large-scale surveys of the older population. Collecting and modeling data on loneliness across individual lives is an important, but complicated, task for future research. Second, our analyses for the full period of interest (1998-2016) are, by necessity, based on a simple yes-no measure of loneliness included in the HRS CES-D index. Comparison of results based on this simple measure and results based on the multi-dimensional UCLA index for 2008-2016 show little difference, but we hesitate to make strong conclusions based on the use of the single yes-no CES-D loneliness measure. Third, our efforts to quantify the role of loneliness in accounting for observed health disparities (by race/ethnicity and educational attainment) should be viewed as a first step. Given the very limited information available on these relationships in existing research, we have chosen to estimate relatively simple models in an effort to provide an initial, descriptive picture of the role of loneliness. Subsequent extensions of this work should focus on extending our models to better understand how the statistically significant and substantively meaningful role of loneliness in accounting for health disparities may reflect other individual, family, and social network characteristics associated with health, loneliness, and race/ethnicity or educational attainment. Fourth, we have not considered social isolation. While it is clear that loneliness and isolation are not the same thing, they are related and efforts to understand the role of loneliness per se may benefit from more careful conceptual and analytical distinction between these two related concepts.

Despite these limitations, we believe that our analyses provide a much-needed descriptive basis upon which to build. It is clear that loneliness is an important correlate of health at older ages that is associated with other well-studied dimensions of health stratification. Growth in attention to loneliness will surely accelerate in response to the fundamental life changes that have accompanied the Covid-19 pandemic, making continued investment in the development of a demography of loneliness at older ages even more important.

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Figure 1: Trends in loneliness, by sex, 1998-2016: CES-D and UCLA 11-item measures

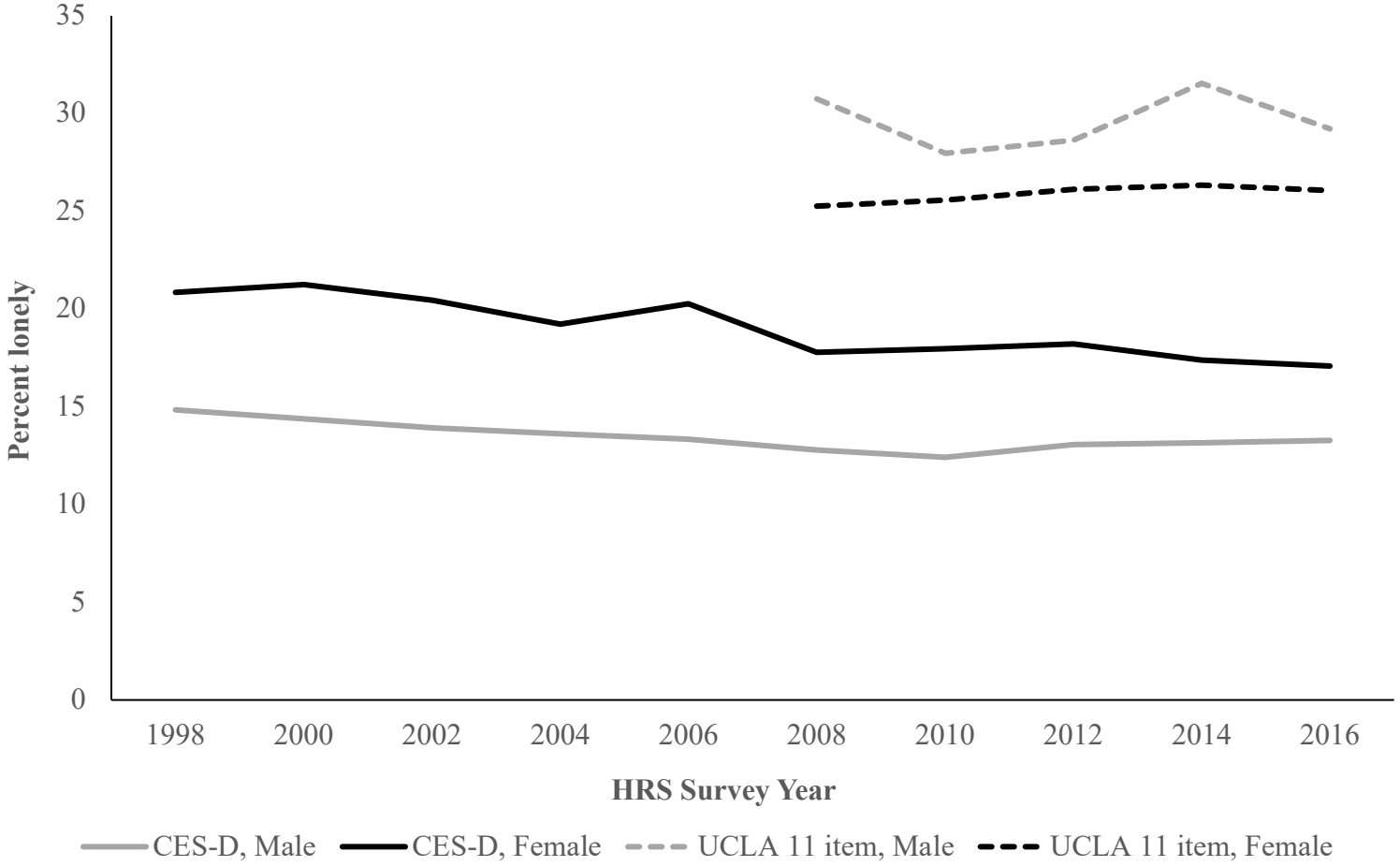

Figure 2: Loneliness, by sex, race/ethnicity, educational attainment, and region of residence (1998-2016): CES-D measure

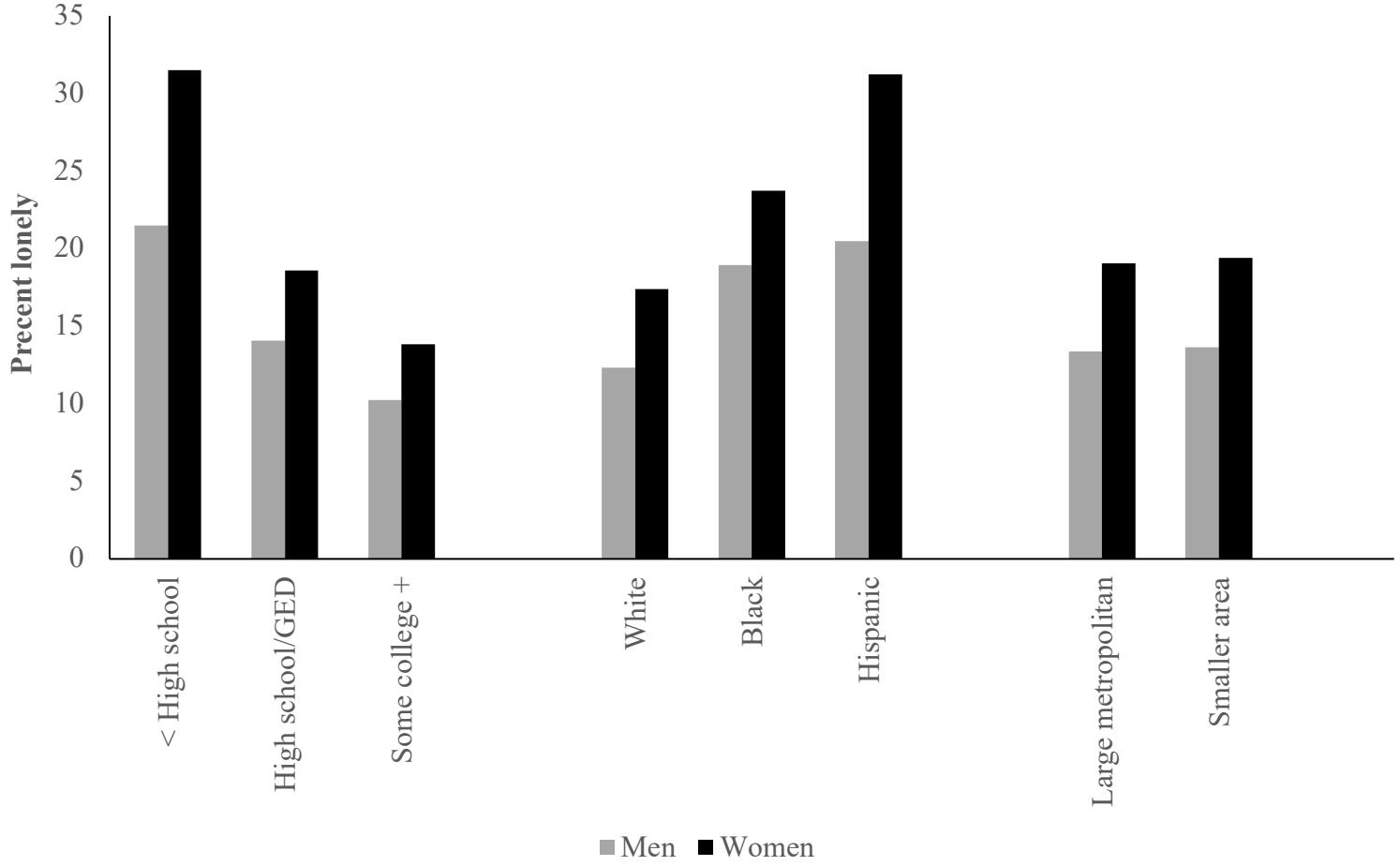

Table 1 Life expectancy at age 55 (lonely, not lonely, total), by sex, race/ethnicity, educational attainment, region of residence, and time period

	1998-2006 Life expectancy at age 55 (years)				2008-2016 Life expectancy at age 55 (years)			
Men	Lonely	Not lonely	Total	% lonely	Lonely	Not lonely	Total	% lonely
Race/ethnicity								
Whites	3.18	21.13	24.31	13%	3.03	22.56	25.59	12%
Blacks	4.43	16.53	20.96	21%	4.03	18.78	22.82	18%
Hispanics	6.51	20.02	26.53	25%	5.82	21.64	27.46	21%
Educational attainment								
Low	4.97	17.18	22.15	22%	4.77	18.23	23.00	21%
Middle	3.52	20.01	23.53	15%	3.37	21.19	24.57	14%
High	2.86	22.93	25.79	11%	3.07	24.80	27.87	11%
Region of residence								
Large metropolitan	3.40	20.66	24.07	14%	3.37	22.67	26.04	13%
Other	3.62	20.55	24.17	15%	3.29	21.04	24.32	14%
Women								
Race/ethnicity								
Whites	5.35	22.51	27.86	19%	4.64	24.22	28.86	16%
Blacks	6.94	18.44	25.39	27%	5.99	21.14	27.13	22%
Hispanics	10.65	19.51	30.15	35%	10.20	20.87	31.07	33%
Educational attainment								
Low	8.23	17.40	25.64	32%	8.49	18.44	26.93	32%
Middle	5.59	22.32	27.91	20%	5.24	23.14	28.38	18%
High	4.77	24.54	29.31	16%	4.51	26.50	31.01	15%
Region of residence								
Large metropolitan	5.87	22.01	27.88	21%	5.34	23.72	29.06	18%
Smaller arear	5.84	21.49	27.34	21%	5.09	23.15	28.24	18%

Table 2 Decomposition of effects of race/ethnicity, educational attainment, and region on disability into direct and indirect effects via loneliness (CES-D loneliness), by sex, 1998-2016

	Black		Hispanic		High school		BA+		Smaller area	
	Log-odds	%	Log-odds	%	Log-odds	%	Log-odds	%	Log-odds	%
Panel A: Men										
Total effect	0.230**	100	0.328***	100	-0.191**	100	-0.290***	100	0.069	100
	(0.069)		(0.079)		(0.062)		(0.060)		(0.049)	
Direct effect	0.223**	96.9	0.311***	94.9	-0.167**	87.5	-0.257***	88.6	0.063	91.0
	(0.069)		(0.079)		(0.062)		(0.060)		(0.049)	
Indirect effect	0.007	3.1	0.017	5.1	-0.024+	12.5	-0.033*	11.4	0.006	9.0
	(0.014)		(0.014)		(0.014)		(0.014)		(0.014)	
N (unweighted)	33998									
Panel B: Women										
Total effect	0.416***	100	0.390***	100	-0.255***	100	-0.314***	100	0.014	100
	(0.047)		(0.065)		(0.043)		(0.046)		(0.036)	
Direct effect	0.416***	100.1	0.351***	91.1	-0.234***	91.8	-0.283***	90.1	0.012	90.1
	(0.047)		(0.065)		(0.043)		(0.046)		(0.036)	
Indirect effect	-0.000	-0.1	0.039***	9.9	-0.021*	8.2	-0.031**	9.9	0.002	10.9
	(0.010)		(0.010)		(0.010)		(0.010)		(0.010)	
N (unweighted)	51770									

Note: Covariates include age, age squared, marital status, working status, logged household total income in previous year, and the baseline large muscle index. When examining effects of a specific stratification variable (e.g., race/ethnicity), we also include the other two stratification variables as covariates in the regression models (e.g., educational attainment and region).
Standard errors in parentheses. *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$, + $p < 0.10$ (two-tailed test).

Table 3 Decomposition of effects of race/ethnicity, educational attainment, and region on mortality into direct and indirect effects via loneliness (CES-D loneliness), by sex, 1998-2016

	Black		Hispanic		High school		BA+		Smaller area	
	Log-odds	%	Log-odds	%	Log-odds	%	Log-odds	%	Log-odds	%
Panel A: Men										
Total effect	0.058	100	-0.216*	100	-0.112*	100	-0.284***	100	0.061	100
	(0.069)		(0.097)		(0.056)		(0.058)		(0.047)	
Direct effect	0.056	96.1	-0.229*	105.8	-0.096+	86.0	-0.264***	93.1	0.061	101.2
	(0.069)		(0.097)		(0.057)		(0.059)		(0.047)	
Indirect effect	0.002	3.9	0.012+	-5.8	-0.016*	14.0	-0.019**	6.9	-0.001	-1.2
	(0.006)		(0.007)		(0.007)		(0.007)		(0.006)	
N (unweighted)	56799									
Panel B: Women										
Total effect	0.107+	100	-0.470***	100	-0.176***	100	-0.316***	100	0.032	100
	(0.059)		(0.091)		(0.051)		(0.056)		(0.044)	
Direct effect	0.105+	98.4	-0.500***	106.5	-0.155**	88.0	-0.289***	91.1	0.032	99.9
	(0.059)		(0.091)		(0.051)		(0.056)		(0.044)	
Indirect effect	0.002	1.6	0.031***	-6.5	-0.021**	12.0	-0.028***	8.9	0.000	0.1
	(0.006)		(0.007)		(0.007)		(0.008)		(0.006)	
N (unweighted)	81432									

Note: Covariates include age, age squared, marital status, working status, logged household total income in previous year, and the baseline large muscle index. When examining effects of a specific stratification variable (e.g., race/ethnicity), we also include the other two stratification variables as covariates in the regression models (e.g., educational attainment and region).
Standard errors in parentheses. *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$, + $p < 0.10$ (two-tailed test).

Table 4 Decomposition of effects of race/ethnicity, educational attainment, and region on cognitive impairment into direct and indirect effects via loneliness (CES-D loneliness), by sex, 1998-2016

	Black		Hispanic		High school		BA+		Smaller areas	
	Log-odds	%	Log-odds	%	Log-odds	%	Log-odds	%	Log-odds	%
Outcome: CIND										
Panel A: Men										
Total effect	0.929***	100	0.501***	100	-0.802***	100	-1.378***	100	0.117*	100
	(0.086)		(0.104)		(0.073)		(0.073)		(0.058)	
Direct effect	0.924***	99.4	0.486***	96.9	-0.787***	98.2	-1.360***	98.7	0.116*	99.2
	(0.086)		(0.104)		(0.073)		(0.073)		(0.058)	
Indirect effect	0.005	0.6	0.015	3.1	-0.014	1.8	-0.018	1.3	0.001	0.8
	(0.011)		(0.011)		(0.011)		(0.011)		(0.011)	
N(unweighted)	22322									
Panel B: Women										
Total effect	1.123***	100	0.842***	100	-0.785***	100	-1.225***	100	0.147**	100
	(0.058)		(0.073)		(0.050)		(0.053)		(0.042)	
Direct effect	1.123***	100.1	0.808***	95.9	-0.766***	97.6	-1.198***	97.8	0.147***	99.8
	(0.058)		(0.073)		(0.049)		(0.053)		(0.042)	
Indirect effect	-0.001	-0.1	0.034**	4.1	-0.019+	2.4	-0.027**	2.2	-0.000	-0.2
	(0.010)		(0.011)		(0.010)		(0.010)		(0.010)	
N(unweighted)	38352									
Outcome: Dementia										
Panel C: Men										
Total effect	1.150***	100	0.417	100	-1.399***	100	-1.774***	100	0.409**	100
	(0.221)		(0.265)		(0.168)		(0.170)		(0.137)	
Direct effect	1.147***	99.7	0.406	97.5	-1.389***	99.3	-1.761***	99.3	0.408**	98.8
	(0.221)		(0.265)		(0.168)		(0.171)		(0.138)	
Indirect effect	0.004	0.3	0.011	2.5	-0.010	0.7	-0.013	0.7	0.001	0.2
	(0.008)		(0.010)		(0.010)		(0.011)		(0.007)	
N(unweighted)	22322									
Panel D: Women										
Total effect	1.483***	100	1.174***	100	-0.934***	100	-1.536***	100	0.267**	100

	(0.117)		(0.145)		(0.090)		(0.108)		(0.088)	
Direct effect	1.484***	100.1	1.138***	96.9	-0.914***	97.9	-1.508***	98.2	0.268**	100.1
	(0.117)		(0.146)		(0.090)		(0.108)		(0.088)	
Indirect effect	-0.001	-0.1	0.036**	3.1	-0.020+	2.1	-0.028*	1.8	-0.000	-0.1
	(0.010)		(0.013)		(0.011)		(0.012)		(0.010)	
N(unweighted)	38352									

Note: Covariates include age, age squared, marital status, working status, logged household total income in previous year, and the baseline large muscle index. When examining effects of a specific stratification variable (e.g., race/ethnicity), we also include the other two stratification variables as covariates in the regression models (e.g., educational attainment and region).
Standard errors in parentheses. *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$, + $p < 0.10$ (two-tailed test).

Table A1 Sample size across different health outcomes

	Disability		Cognitive impairment		Mortality	
	N of resp	**N of obs**	**N of resp**	**N of obs**	**N of resp**	**N of obs**
Panel A: CES-D loneliness (1998-2016)[a]						
Excluding missing values on loneliness	31,513	157,002	29,272	140,778	31,513	157,002
Restricting to respondents who were not disabled, with normal cognitive function upon entry into HRS	21,390	105,618	17,361	88,255	NA	NA
Having non-missing and valid values of outcome at wave *t* and *t +1* (Individuals' last observation does not enter model)	19,196	86,267	14,832	61,088	29,237	140,730
Excluding missing values on covariates	19,092	85,768	14,721	60,674	28,711	138,231
Panel B: 11-item UCLA loneliness scale (2008-2016)[a]						
Excluding missing values on loneliness	17,683	30,065	16,480	25,023	17,683	30,065
Restricting to respondents who were not disabled, with normal cognitive function upon entry into HRS	12,622	21,517	10,790	18,528	NA	NA
Having non-missing and valid values of outcome at wave *t* and *t +1* (Individuals' last observation does not enter model)	10,910	16,421	8,028	10,056	16,480	25,023
Excluding missing values on covariates	10,849	16,336	7,982	10,000	16,230	24,665

Notes: Cognitive impairment is available until wave 12 (2014). N of resp = N of respondents; N of obs = N of observations (person-waves).

Table A2 Decomposition of effects of race/ethnicity, educational attainment, and region on disability into direct and indirect effects via loneliness (11-item UCLA loneliness), by sex, 2008-2016

	Black		Hispanic		High School		BA+		Smaller area	
	Log-odds	%	Log-odds	%	Log-odds	%	Log-odds	%	Log-odds	%
Panel A: Men										
Total effect	-0.118	100	0.315+	100	-0.364*	100	-0.398*	100	-0.073	100
	(0.183)		(0.177)		(0.164)		(0.158)		(0.120)	
Direct effect	-0.089	75.0	0.339+	107.6	-0.318+	87.5	-0.317*	79.5	-0.092	127.1
	(0.183)		(0.177)		(0.164)		(0.158)		(0.120)	
Indirect effect	-0.030	25.0	-0.024	-7.6	-0.046	12.5	-0.082	20.5	0.020	-27.1
	(0.053)		(0.052)		(0.052)		(0.053)		(0.052)	
N (unweighted)	6681									
Panel B: Women										
Total effect	0.494***	100	0.398*	100	-0.279*	100	-0.342**	100	-0.062	100
	(0.120)		(0.155)		(0.120)		(0.126)		(0.093)	
Direct effect	0.479***	97.0	0.407**	102.5	-0.243*	87.0	-0.285*	83.2	-0.075	120.7
	(0.120)		(0.155)		(0.119)		(0.126)		(0.093)	
Indirect effect	0.015	3.0	-0.010	-2.5	-0.036	13.0	-0.058+	16.8	0.013	-20.7
	(0.028)		(0.028)		(0.029)		(0.030)		(0.028)	
N (unweighted)	9655									

Note: Covariates include age, age squared, marital status, working status, logged household total income in previous year, and the baseline large muscle index. When examining effects of a specific stratification variable (e.g., race/ethnicity), we also include the other two stratification variables as covariates in the regression models (e.g., educational attainment and region).
Standard errors in parentheses. *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$, + $p < 0.10$ (two-tailed test).

Table A3 Decomposition of effects of race/ethnicity, educational attainment, and region on cognitive impairment into direct and indirect effects via loneliness (11-item UCLA loneliness), by sex, 2008-2016

	Black		Hispanic		High school		BA+		Smaller area	
	Log-odds	%	Log-odds	%	Log-odds	%	Log-odds	%	Log-odds	%
Outcome: CIND										
Panel A: Men										
Total effect	0.885***	100	0.198	100	-0.965***	100	-1.569***	100	0.137	100
	(0.221)		(0.244)		(0.209)		(0.208)		(0.149)	
Direct effect	0.886***	100.1	0.198	100.3	-0.963***	98.8	-1.565***	98.8	0.136	99.6
	(0.221)		(0.244)		(0.210)		(0.209)		(0.149)	
Indirect effect	-0.001	-0.1	-0.001	-0.3	-0.002	0.2	-0.003	0.2	0.001	0.4
	(0.005)		(0.004)		(0.010)		(0.019)		(0.004)	
N (unweighted)	3765									
Panel B: Women										
Total effect	1.165***	100	0.560**	100	-1.117***	100	-1.652***	100	0.096	100
	(0.155)		(0.196)		(0.147)		(0.154)		(0.112)	
Direct effect	1.149***	98.6	0.558**	99.5	-1.067***	95.5	-1.586***	95.9	0.087	90.8
	(0.155)		(0.196)		(0.146)		(0.153)		(0.112)	
Indirect effect	0.016	1.4	0.003	0.5	-0.051	4.5	-0.067+	4.1	0.009	9.2
	(0.035)		(0.035)		(0.037)		(0.038)		(0.035)	
N (unweighted)	6235									
Outcome: Dementia										
Panel C: Men										
Total effect	1.673***	100	0.505	100	-1.552***	100	-1.991***	100	0.690*	100
	(0.452)		(0.903)		(0.434)		(0.475)		(0.304)	
Direct effect	1.678***	100.3	0.509	100.8	-1.541**	99.3	-1.971***	99.0	0.687*	99.5
	(0.451)		(0.908)		(0.443)		(0.492)		(0.306)	
Indirect effect	-0.004	-0.3	-0.004	-0.8	-0.011	0.7	-0.021	1.0	0.003	0.5
	(0.019)		(0.018)		(0.030)		(0.051)		(0.018)	
N (unweighted)	3765									
Panel D: Women										
Total effect	2.091***	100	0.569	100	-1.367***	100	-2.047***	100	0.511*	100

	(0.297)		(0.439)		(0.261)		(0.303)		(0.226)	
Direct effect	2.071***	99.1	0.565	99.4	-1.305***	95.4	-1.964***	96.0	0.500*	97.9
	(0.296)		(0.439)		(0.257)		(0.303)		(0.226)	
Indirect effect	0.020	0.9	0.003	0.6	-0.062	4.6	-0.082	4.0	0.011	2.1
	(0.044)		(0.043)		(0.049)		(0.054)		(0.043)	
N (unweighted)	6235									

Note: Covariates include age, age squared, marital status, working status, logged household total income in previous year, and the baseline large muscle index. When examining effects of a specific stratification variable (e.g., race/ethnicity), we also include the other two stratification variables as covariates in the regression models (e.g., educational attainment and region).
Standard errors in parentheses. *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$, + $p < 0.10$ (two-tailed test).

Table A4 Decomposition of effects of race/ethnicity, educational attainment, and region on mortality into direct and indirect effects via loneliness (11-item UCLA loneliness), by sex, 2008-2016

	Black		Hispanic		High school		BA+		Smaller area	
	Log-odds	%	Log-odds	%	Log-odds	%	Log-odds	%	Log-odds	%
Panel A: Men										
Total effect	0.218	100	-0.550*	100	-0.352*	100	-0.560***	100	0.127	100
	(0.171)		(0.261)		(0.142)		(0.139)		(0.109)	
Direct effect	0.225	103.0	-0.548*	99.7	-0.344*	97.7	-0.546***	97.5	0.125	98.4
	(0.171)		(0.261)		(0.142)		(0.140)		(0.109)	
Indirect effect	-0.007	-3.0	-0.002	0.3	-0.008	2.3	-0.014	2.5	0.002	1.6
	(0.010)		(0.009)		(0.010)		(0.013)		(0.009)	
N (unweighted)	10341									
Panel B: Women										
Total effect	0.380**	100	-0.532*	100	-0.226+	100	-0.450**	100	0.154	100
	(0.142)		(0.208)		(0.132)		(0.140)		(0.103)	
Direct effect	0.373**	98.2	-0.539*	101.2	-0.192	84.8	-0.397**	88.2	0.144	93.2
	(0.142)		(0.208)		(0.132)		(0.141)		(0.103)	
Indirect effect	0.007	1.8	0.006	-1.2	-0.034	15.2	-0.053*	11.8	0.011	6.8
	(0.025)		(0.025)		(0.026)		(0.027)		(0.025)	
N (unweighted)	14324									

Note: Covariates include age, age squared, marital status, working status, logged household total income in previous year, and the baseline large muscle index. When examining effects of a specific stratification variable (e.g., race/ethnicity), we also include the other two stratification variables as covariates in the regression models (e.g., educational attainment and region).
Standard errors in parentheses. *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$, + $p < 0.10$ (two-tailed test).

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